Introduction to Anaerobic Digester Biogas Systems

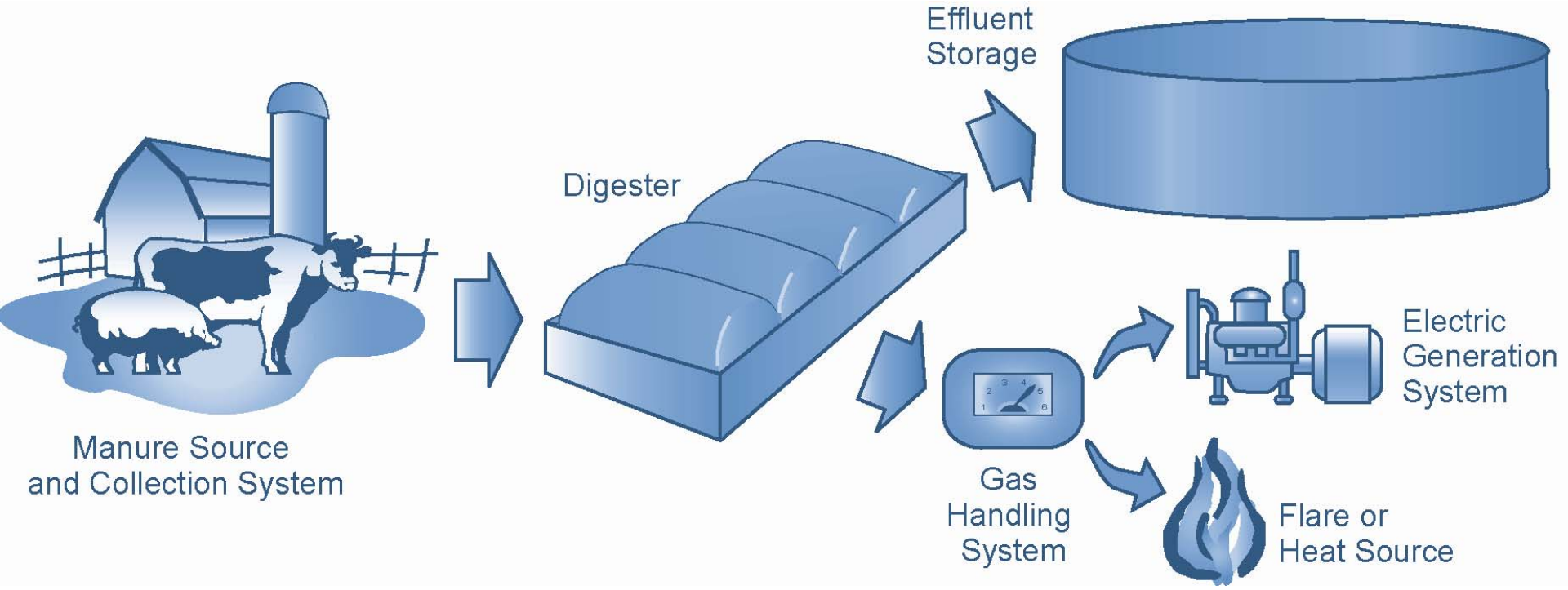
AgSTAR

NPPD

Nebraska Public Power District

Components of a Biogas System

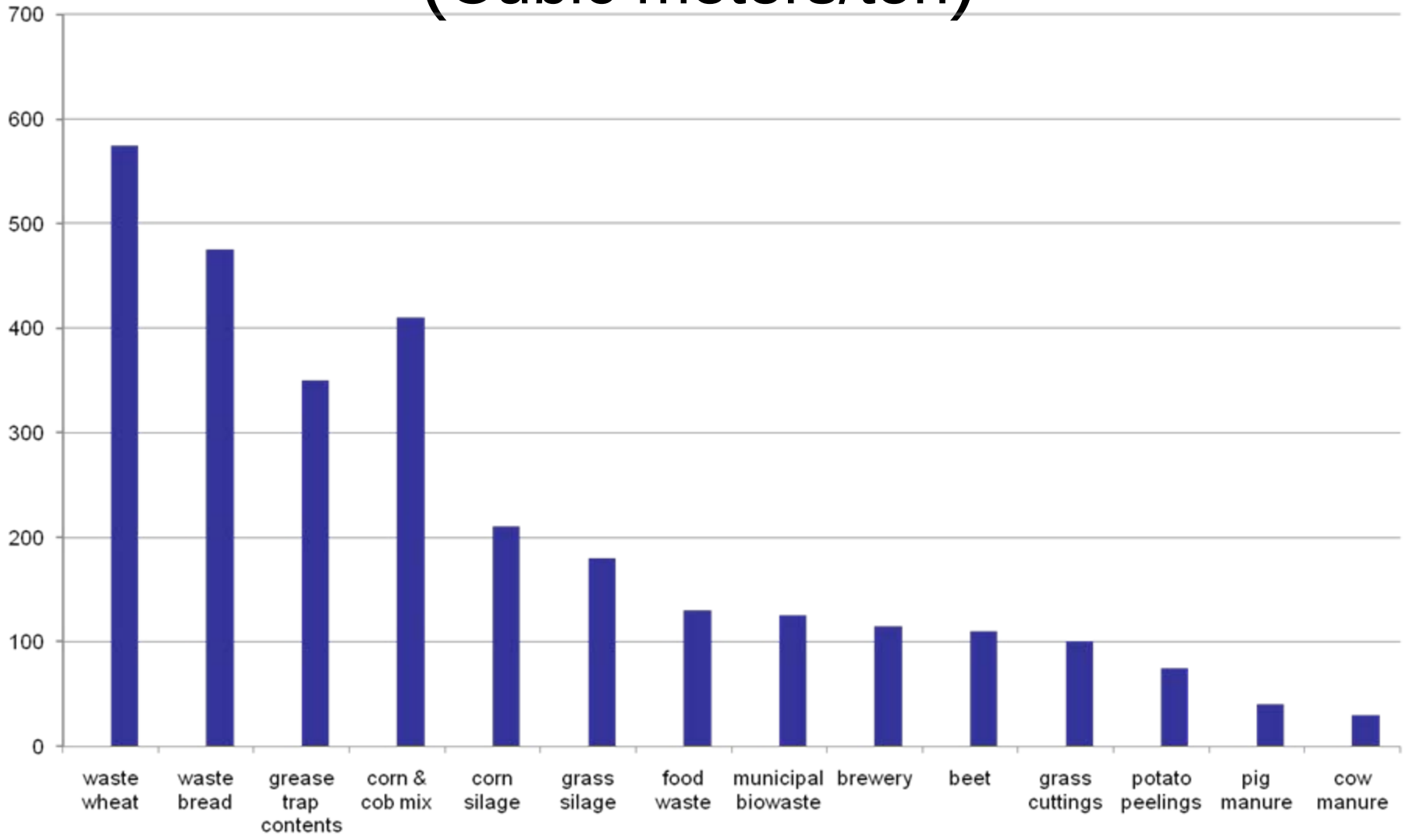
- Manure Collection
- Anaerobic Digester
- Effluent Storage
- Biogas Handling
- Biogas Use


Effluent
Storage
Digester
Electric
Generation
System
Manure Source
and Collection System
Gas
Handling
System
Flare or
Heat Source

Manure Collection

- Raw Manure (8-25% solids)
- Manure Handling
  - Liquid Manure
    - <3% solids
    - Usually collected by flushing
  - Slurry Manure
    - 3-10% solids
    - Typically collected by scraping or in pits
- Manure Handling
  - Semi-Solid Manure
    - 10-20% solids
    - Typically collected by scraping
    - No water added
  - Solid Manure
    - >20% solids
    - Usually moved by a scoop loader

Digester Feedstock
(Cubic meters/ton)



Digester Types and Characteristics

Exhibit 1-1 Summary Characteristics of Digester Technologies

Characteristics	Covered Lagoon	Complete Mix Digester	Plug Flow Digester	Fixed Film
Digestion Vessel	Deep Lagoon	Round/Square In/Above-Ground Tank	Rectangular In-Ground Tank	Above Ground Tank
Level of Technology	Low	Medium	Low	Medium
Supplemental Heat	No	Yes	Yes	No
Total Solids	0.5 - 3%	3 - 10%	11 - 13%	3%
Solids Characteristics	Fine	Coarse	Coarse	Very Fine
HRT* (days)	40 - 60	15+	15+	2-3
Farm Type	Dairy, Hog	Dairy, Hog	Dairy Only	Dairy, Hog
Optimum Location	Temperate and Warm Climates	All Climates	All Climates	Temperate and Warm

* Hydraulic Retention Time (HRT) is the average number of days a volume of manure remains in the digester.

Swine Digester Examples

Swine Digester Examples

Dairy Digester Examples

Effluent Storage

- Stabilized organic solution
- Good value as a fertilizer
- Storage needed as nutrients cannot be land applied year round
  - May be applied through a center pivot
- Typically storage must be adequate to meet farm needs during non-growing season

Biogas Handling

- Handling system moves biogas from the digester to energy end use
- Includes piping, pump or blower, gas meter, pressure regulator, and condensate drains; maybe gas scrubber
- Biogas builds pressure inside the digester – it's removed by putting a slight vacuum on the collection pipe from the digester

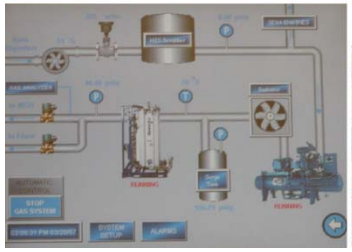
Recip. Engines 40-250kW

COMPONENTS

Gas Handling

Engine Controller

Electric Metering



Biogas Use

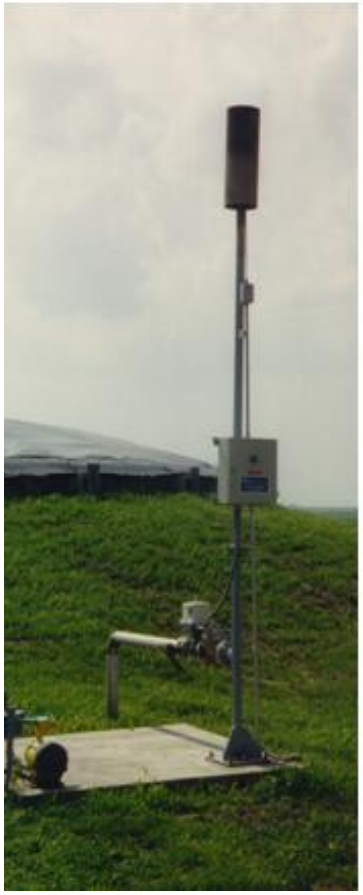
- Digester Biogas – usually 60-80% methane, heating value of 600-800 Btu/ft^3
- Most equipment that uses natural gas, propane, butane can be fueled by biogas
- Opportunities for equipment fueled on coal and fuel oil as well.

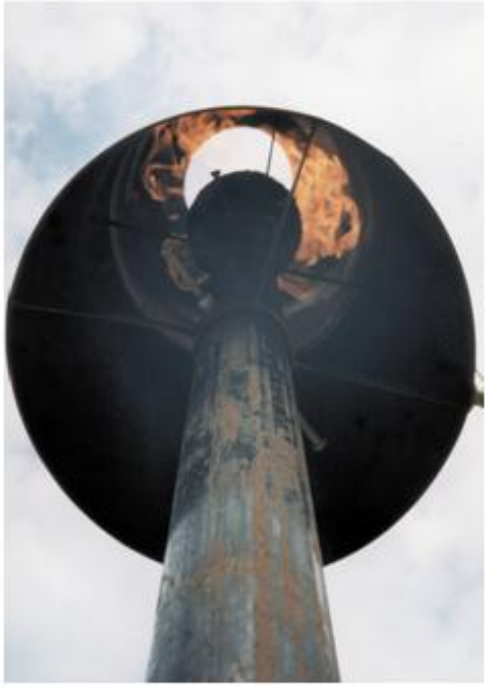
Biogas Use

- Electricity
  - Internal combustion engines, microturbines, fuel cells
  - For on-farm use and/or sale to grid
- Co-generation (combined heat and power)
  - Capture heat from engine for electricity generation to warm digester
  - Could provide heat, hot water or steam for farm or neighboring operations when heat available exceeds the needs of the digester
- As a fuel for Boilers and Heaters
- As a fuel providing heat for Chilling/Refrigeration

Biogas Use

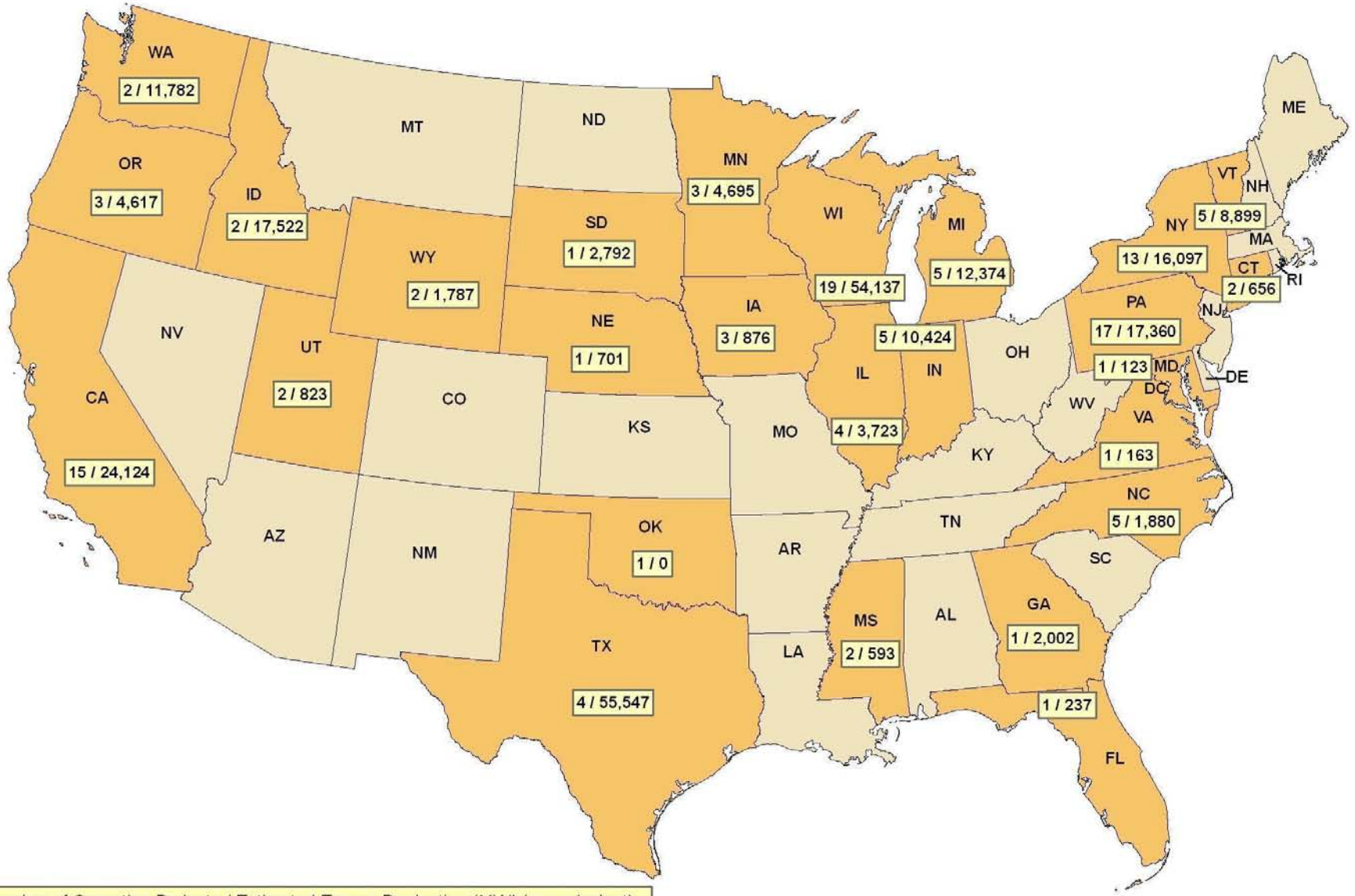
Odor Control and Greenhouse Gas Mitigation (and backup)





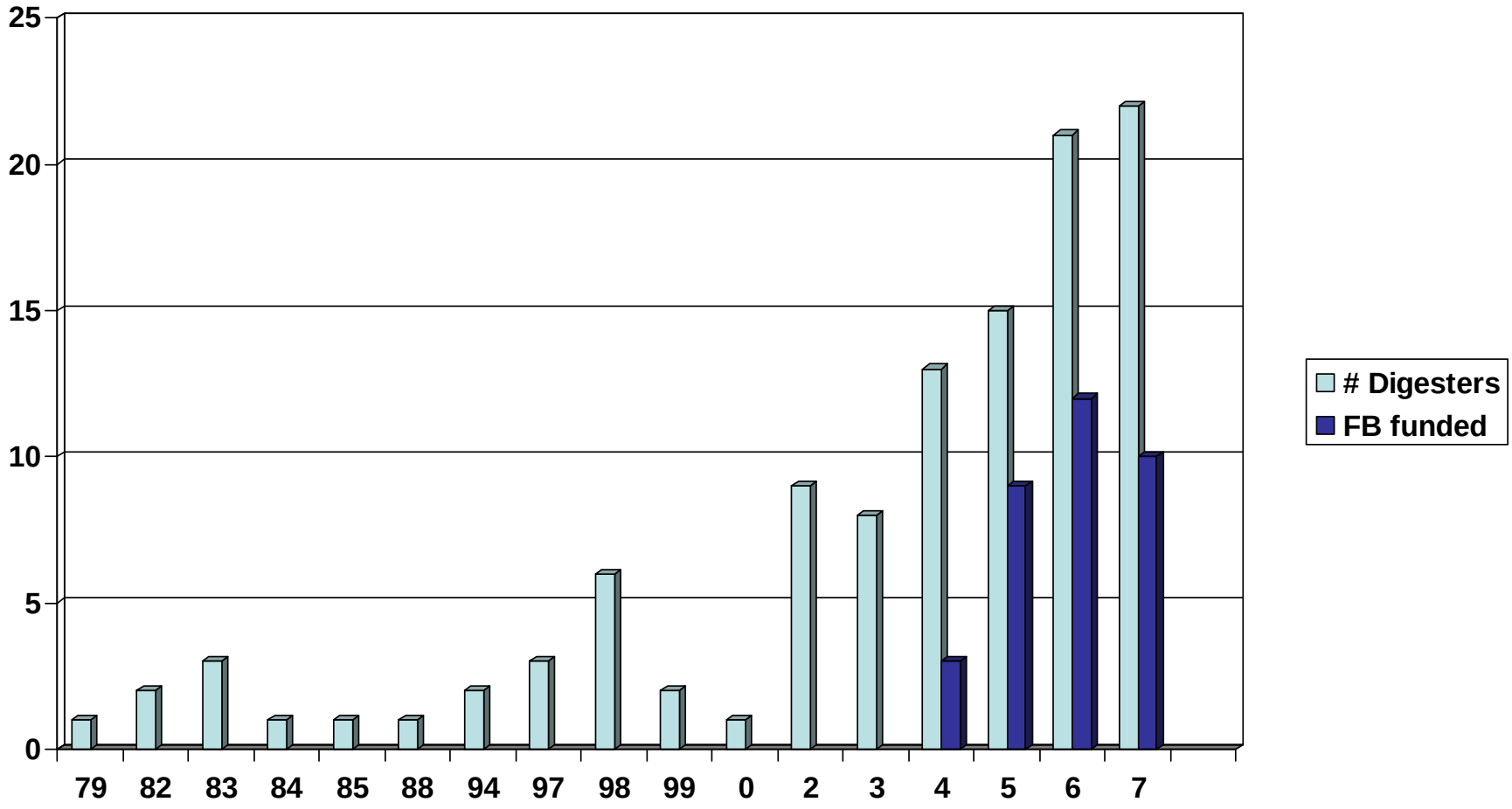
Biogas Use

2008 Operating Manure Digesters



Number of Operating Projects / Estimated Energy Production (MWh/yr equivalent)
Total Operating Projects: 120
Total Estimated Energy Production: 253,933 MWh/yr equivalent

Number of Digesters Becoming Operational Per Year (1979-2008)



Reasons for Success

- The owner/operator:
  - realized the benefits biogas technology had to offer and wanted to make it work.
  - had some mechanical knowledge and ability and had access to technical support.
  - increased the profitability of biogas systems through the utilization and sale of manure byproducts.
- The designer/builder built systems that were compatible with farm operation.

Reasons for Failure

- The owner/operator:
  - did not have the skills or the time required.
  - digester systems were not compatible with manure handling.
  - inadequate training and technical support for their systems.
- The designer/builders:
  - sold “cookie cutter” designs to farms.
  - installed the wrong type of equipment.
- The systems:
  - became too expensive to maintain and repair because of poor system design.
  - provided no financial returns or returns diminished over time.
- Farms went out of business due to non-digester factors.

Benefits of Biogas Projects

- On and Off-Site Farm Energy
- Reduced Odors
- High Quality Fertilizer
- Reduced Surface and Groundwater Contamination
- Pathogen Reduction
- Fiber Recovery and Use

Preliminary Screening for Project Opportunities

- Is your confined livestock facility ‘large”?
- In manure production and collection stable year round?
- Is your manure management compatible with biogas technology?
- Is there a use for the energy recovered?
- Will you be able to manage the system effectively?

Facility Size

Exhibit 2-1 Checklist for Facility Characteristics

1.	Do you have at least 500 cows/steer or 2,000 pigs at your facility?	Yes ❑	No ❑
2.	Are these animals in confinement all year round?	Yes ❑	No ❑
3.	The average animal population does not vary by more than 20% in a year?	Yes ❑	No ❑

If the answer is **YES** to all the above questions, your facility is in good shape. Proceed to the next section. If the answer is **NO** to one or more of the above questions, the production and utilization of biogas as a fuel may not be suitable for your facility. For biogas production and utilization to succeed, a continuous and relatively consistent flow of biogas is required. However, collecting and flaring biogas can reduce odors. Therefore, also proceed to the next section if you have the need for an effective odor control strategy.

Manure Management

Exhibit 2-3 Checklist for Manure Management

1.	Do you collect manure as a liquid/slurry/semi-solid?	Yes ❑	No ❑
2.	Is the manure collected and delivered to one common point?	Yes ❑	No ❑
3.	Is the manure collected daily or every other day?	Yes ❑	No ❑
4.	Is the manure sand relatively free of clumps of bedding and other material, such as rocks, stones, and straw?	Yes ❑	No ❑

If the answer is **YES** to all the above questions, manure management criterion is satisfied. If the answer is **NO**, to any of the questions, you may need to change your manure management routine. See text.

Energy Use

Exhibit 2-4 Checklist for Energy Use

1.	Are there on-site uses (e.g., heating, electricity, refrigeration) for the energy recovered?	Yes ❑	No ❑
2.	Are there facilities nearby that could use the biogas?	Yes ❑	No ❑
3.	Are there electric power distribution systems in your area that could or do buy power from projects such as biogas recovery?	Yes ❑	No ❑

If the answer is **YES** to any of the above questions,
the energy use criterion is satisfied for initial screening purposes.

Project Management

Exhibit 2-5 Checklist for Management

1.	Is there a "screw driver friendly" person on the farm that can operate and maintain the technical equipment?	Yes ❑	No ❑
2.	If YES, can this person spend about 30 minutes a day to manage the system and 1 to 10 hours on occasional repair and maintenance?	Yes ❑	No ❑
3.	Will this person be available to make repairs during high labor use events at the farm?	Yes ❑	No ❑
4.	Is technical support (access to repair parts and services) available?	Yes ❑	No ❑
5.	Will the owner be overseeing system operations?	Yes ❑	No ❑

If the answers are **YES** to the above questions, the management criterion is satisfied.
In general, if the owner is committed to seeing the system succeed, it will.

Initial Appraisal

Exhibit 2-6 Initial Appraisal Results Checklist

1.	Are there at least 500 cows/steers or 2,000 hogs in confinement at your facility year round?	Yes ❑	No ❑
2.	Is your manure management compatible with biogas technology?	Yes ❑	No ❑
3.	Can you use the energy?	Yes ❑	No ❑
4.	Can you be a good operator?	Yes ❑	No ❑

If the answer is **YES** to all questions, there are promising options for gas recovery. Proceed to Chapter 3, where the project technical and economic feasibility will be determined. If you answered **NO** to any of the questions, you may need to make some changes. Read the relevant section, evaluate the cost of changes required, if any, before proceeding.

Vision

- Create a multi-billion dollar industry based on methane capture and use at livestock operations
  - Enable innovative business models that create equity for farmers and rural communities and advance their energy independence
  - Secure markets for energy, nutrients, value-added products, and carbon
  - Establish an environment that favors project establishment
  - Facilitate next generation technologies that advance superior environmental performance
- ** Reap the environmental and energy benefits

Market Potential

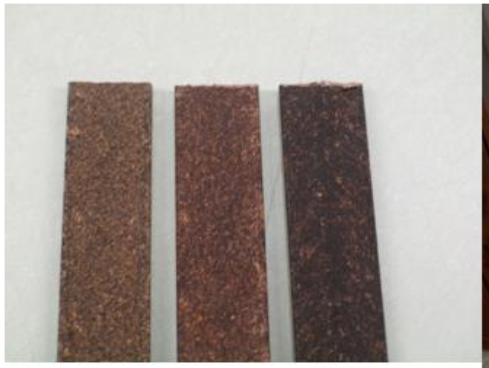
Figure 1. Market Opportunities for Biogas Recovery Systems at Animal Feeding Operations

Animal Sector	Candidate Farms	Electricity Generating Potential	
		MW	MWh/year
Swine	4,300	363	3,184,000
Dairy	2,600	359	3,148,000
Total	6,900	722	6,332,000

Major Project Drivers

- More project developers joining the industry:
  - New business models require less up-front cost and risk to farmers
  - Energy generation more critical
  - Carbon and renewable energy credits growing
  - Most new entrants are business and energy savvy
- Increase in 3rd party investment
- Emergence of complete mix designs suitable for co-mingling in U.S. market (especially dairy)
- Market developing for dairy manure fibers (up to 60% of project revenue)
  - Bedding
  - Potting soil (peat moss replacement)
  - Fiber boards (not yet proven but shows promise)
- Continuing - AD systems help reduce odors, comply with environmental regulations, nutrient management plans, and increase farm productivity/economics.

Value Added Benefits of AD Systems



Fiberboard/Decking

Building Materials

Horticulture – soil/peat replacement

Cow Pots


Farm Fresh
TOMATOES


Locally Grown
Vine Ripened
Barham's Best Greenhouse Tomatoes

Interest and Innovation

RATH YOUNG PIGNATELLI

RENEWABLE ENERGY UPDATE February 2009

RENEWABLE ENERGY PROVISIONS IN STIMULUS ACT

On February 17, 2009, President Obama signed into law the American Recovery and Reinvestment Act of 2009. This Act, also known as the Stimulus Bill, contains several important energy tax provisions, including:

- Extending the placement-in-service deadline for certain energy sources under section 45 (open-loop biomass, closed-loop biomass, geothermal, landfill gas, trash, qualified hydropower and marine and hydrokinetic) to December 31, 2013;
- Extending the placement-in-service deadline for wind and refined coal under section 45 to December 31, 2012;
- Allowing owners of new renewable energy facilities to claim an upfront 30% investment tax credit under Section 48 instead of claiming the production tax credit under section 45 over 10 years;
- Allowing owners of new renewable energy facilities to elect a tax-free cash grant instead of claiming the investment tax credit;
- Repealing the phase-out of the investment tax credit for tax-exempt bond and subsidized energy financing; and
- Extending 50% "bonus depreciation" for projects placed in service in 2009.

Non-tax provisions include a loan guarantee program for renewable energy projects that is estimated to allow the Department of Energy to guarantee up to $60 billion in new loans.

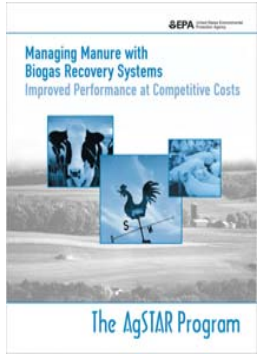
This Update summarizes the provisions of the Act of most interest to developers of, and investors in, renewable energy projects.

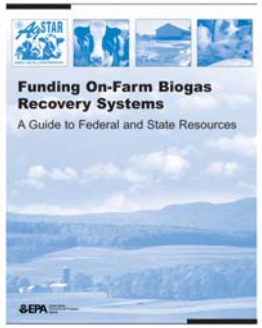
Challenges

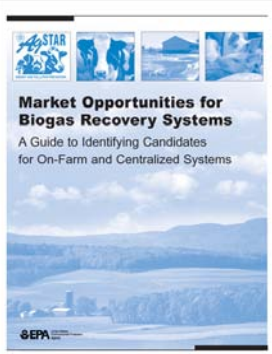
- Energy Policy
  - Local, state, national
  - Interconnect, stand-by, net metering, tariffs
- Regulatory constructs
  - Engine emissions, co-digestion
- Knowledge
- Education
  - Producers, policy makers, regulators

AgSTAR Resources

- General Outreach
  - Annual AgSTAR Conference, AgSTAR Digest newsletter, Farm Extension Events, Workshops
- Project Development
  - *Managing Manure with Biogas Recovery Systems*
  - *Industry Directory*
  - *Funding Guide for Federal and State Resources*
  - *Market Opportunities for Biogas Recovery Systems*
- Technical Analysis
  - A Protocol for Quantifying and Reporting the Performance of Anaerobic Digestion Systems for Livestock Manures
  - Mass Balance Waste Management Evaluations
  - Dairy and Pig Manure Case Studies
- Project Evaluation Tools
  - AgSTAR Handbook - A Manual for Developing Biogas Systems at Commercial Farms in the United States
  - FarmWare - develops project specific feasibility assessments







AA Dairy Shares "Fields of Dreams"

Location	Candor, New York
Project Type	Farm scale
Animal Type	Dairy
Population	550 head milking herd
Baseline System	Pond
Digester Type	Horizontal plug flow
System Designer	RCM International, LLC
Biogas Use	Cogeneration
Generating Capacity	130 kW Caterpillar 3306
Receiving Utility	New York State Electric & Gas Corporation

Before installing its anaerobic digester in 1998, odors from AA Dairy's manure storage and spreading sites were an issue. With plans to double its size to 1,000 cows, AA needed a way to control odors more economically and manage manure more effectively. With installation of the 39,500 ft^3 plug flow digester, the farm not only increased its capacity and reduced odor, but also created revenue streams from electricity generation and sale of its "Fields of Dreams" compost.

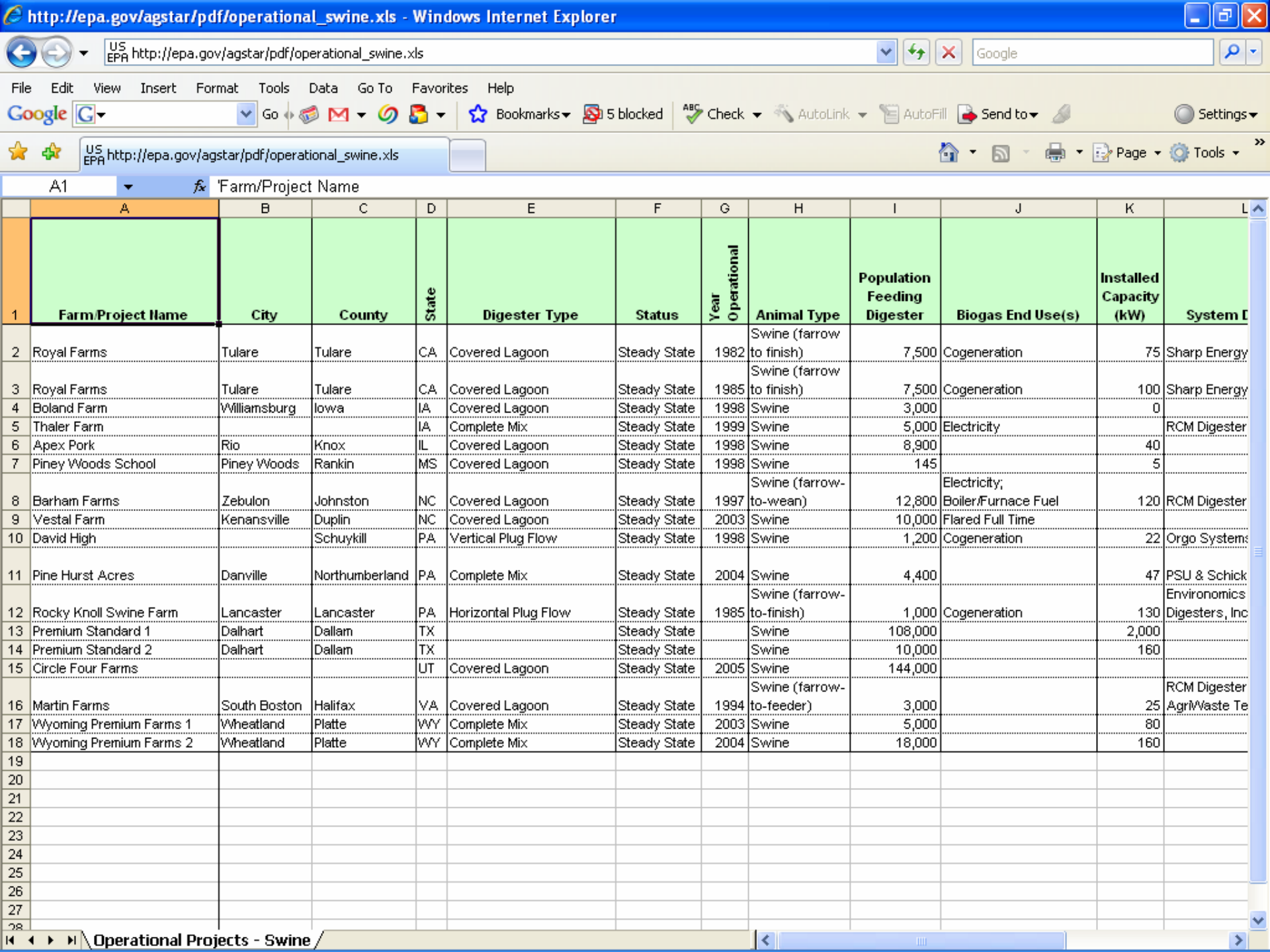
Photo: RCM International, LLC

Designed to handle a capacity of 1,000 cows, the 112-foot digester currently receives approximately 8,600 gallons of manure each day from 550 cows. The manure, scraped from the freestall barn, includes newspaper, sawdust, and shavings that are used for bedding. A flexible cover captures the biogas produced, which is collected, filtered, and pressurized before fueling a 130 kW engine-generator set that produces enough power to operate the farm with excess sold to the local utility.

A screw press separator is used to separate the coarse fiber from the digester effluent, which is then composted and sold as "Fields of Dreams" compost for use as a soil amendment. It is essentially weed-free compost with a dry matter content of 20-30 percent and a pH of about 8. The farm sells various quantities from bagfulls to truckloads. Sale of the compost has helped offset the capital cost of the digester and reduces the rate of phosphorous application to the farm's cropland.

In 1999, AA Dairy received a New York State Governor's Award for Pollution Prevention. AA Dairy's digester includes the following benefits:

- Reduced odor improves community relationships
- The nearly odorless liquid effluent is applied directly to crops with virtually no nutrient loss
- Recovered heat from the engine-generator set heats the digester and hot water reserve, saving propane expense
- Sale of "Fields of Dreams" compost to the community and other farms as a soil amendment generates revenue



	A	B	C	D	E	F	G	H	I	J	K	L
1	Farm/Project Name	City	County	State	Digester Type	Status	Year Operational	Animal Type	Population Feeding Digester	Biogas End Use(s)	Installed Capacity (kW)	System D
2	Royal Farms	Tulare	Tulare	CA	Covered Lagoon	Steady State	1982	Swine (farrow to finish)	7,500	Cogeneration	75	Sharp Energy
3	Royal Farms	Tulare	Tulare	CA	Covered Lagoon	Steady State	1985	Swine (farrow to finish)	7,500	Cogeneration	100	Sharp Energy
4	Boland Farm	Williamsburg	Iowa	IA	Covered Lagoon	Steady State	1998	Swine	3,000		0	
5	Thaler Farm			IA	Complete Mix	Steady State	1999	Swine	5,000	Electricity		RCM Digester
6	Apex Pork	Rio	Knox	IL	Covered Lagoon	Steady State	1998	Swine	8,900		40	
7	Piney Woods School	Piney Woods	Rankin	MS	Covered Lagoon	Steady State	1998	Swine	145		5	
8	Barham Farms	Zebulon	Johnston	NC	Covered Lagoon	Steady State	1997	Swine (farrow-to-wean)	12,800	Electricity; Boiler/Furnace Fuel	120	RCM Digester
9	Vestal Farm	Kenansville	Duplin	NC	Covered Lagoon	Steady State	2003	Swine	10,000	Flared Full Time		
10	David High		Schuykill	PA	Vertical Plug Flow	Steady State	1998	Swine	1,200	Cogeneration	22	Orgo Systems
11	Pine Hurst Acres	Danville	Northumberland	PA	Complete Mix	Steady State	2004	Swine	4,400		47	PSU & Schick
12	Rocky Knoll Swine Farm	Lancaster	Lancaster	PA	Horizontal Plug Flow	Steady State	1985	Swine (farrow-to-finish)	1,000	Cogeneration	130	Environomics Digesters, Inc
13	Premium Standard 1	Dalhart	Dallam	TX		Steady State		Swine	108,000		2,000	
14	Premium Standard 2	Dalhart	Dallam	TX		Steady State		Swine	10,000		160	
15	Circle Four Farms			UT	Covered Lagoon	Steady State	2005	Swine	144,000			
16	Martin Farms	South Boston	Halifax	VA	Covered Lagoon	Steady State	1994	Swine (farrow-to-feeder)	3,000		25	RCM Digester AgriWaste Te
17	Wyoming Premium Farms 1	Wheatland	Platte	WY	Complete Mix	Steady State	2003	Swine	5,000		80	
18	Wyoming Premium Farms 2	Wheatland	Platte	WY	Complete Mix	Steady State	2004	Swine	18,000		160	
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Experts

Interest in anaerobic digestion systems for livestock manure stabilization and energy production is accelerating. To help build on this forward momentum, the AgSTAR Program maintains two informational resources to further assist in the planning and development of digester systems.

Many of the sites listed on this page are not on the EPA Web site. Please see our disclaimer information. EXIT Disclaimer

Industry Directory

The Industry Directory for On-Farm Biogas Recovery Systems (Dec. 2007) (PDF, 43 pp., 876 KB, About PDF) is intended to assist farm owners and others involved in developing anaerobic digestion technologies to identify designers, project developers, energy service providers, equipment manufacturers and distributors, and commodity organizations. If you are interested in being added to the Directory, please complete the online form.

Organizations

Organizations such as state energy offices, USDA field offices, university programs, and non-government organizations can provide technical, financial, and planning assistance for the development of anaerobic digester systems and biogas utilization technologies.

Organization	Contact	Title	Phone	Organization Type	State
Agricultural Sustainability Institute, UC Davis	Tomich, Thomas (tptomich@ucdavis.edu)	Director	530-574-2503	University	CA
USDA Rural Development – California	Clendenin, Charles M (Chuck.Clendenin@ca.usda.gov)	Rural Energy Coordinator	530-792-5825	Government	CA
Western United Dairymen	Marsh, Mike (info@westernuniteddairymen.com)	CEO	209-527-6453	NGO	CA
Iowa Department of Natural Resources	Bodensteiner, Jim (jim.bodensteiner@dnr.iowa.gov)	Biomass Program Manager	515-281-8416	Government	IA
Iowa State University, Department of Agriculture and Biosystems Engineering	Burns, Robert (rburns@iastae.edu)	Associate Professor		University	IA

More information

- AgSTAR Website
  - www.epa.gov/agstar
- Chris Voell
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  - 202-343-9406